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PILOT TESTING OF A QUALITY MANAGEMENT PROVISION FOR CONCRETE PAVEMENT

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16. Abstract

In 1997, the Wisconsin Department of Transportation (WisDOT) piloted a new Quality Management Program (QMP) provision for concrete pavement. This provision provides for contractor test results as the primary means of material acceptance. Piloting was performed on five projects by five different contractors in four WisDOT Districts. Piloting entailed performing the selected tasks of the new provision in parallel with the original contracted pavement provisions. This allowed for trial use of the sampling, testing, documentation and Quality Control Plan portions of the new provision with contract administration and payment based on the original provisions.

Elements of the new QMP provision that were tested included: a contractor quality control plan; aggregate gradation testing; aggregate moisture and ratio of water to cementitious material measurement; air content measurements; statistical evaluation of 28-day compressive strengths; thickness determination by contractor probing; pavement cracking criteria; and profilograph measurements.

Following the provision piloting, feedback was solicited from the contractor and Department staffs involved with the pilot projects. Refinements were made to the provision, based on project feedback. Those involved with the pilot projects agreed that the provision will lead to increased contractor pride, better relationships between contractors and WisDOT, a higher quality product, and better construction control and material documentation. In 1999, the Department plans to use the provision on at least two projects in each of the Department's eight districts.

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PILOT TESTING OF A QUALITY MANAGEMENT PROVISION FOR CONCRETE PAVEMENT

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ABSTRACT

In 1997, the Wisconsin Department of Transportation (WisDOT) piloted a new Quality Management Program (QMP) provision for concrete pavement. This provision provides for contractor test results as the primary means of material acceptance. Piloting was performed on five projects by five different contractors in four WisDOT Districts. Piloting entailed performing the selected tasks of the new provision in parallel with the original contracted pavement provisions. This allowed for trial use of the sampling, testing, documentation and Quality Control Plan portions of the new provision with contract administration and payment based on the original provisions.

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Following the provision piloting, feedback was solicited from the contractor and Department staffs involved with the pilot projects. Refinements were made to the provision, based on project feedback. Those involved with the pilot projects agreed that the provision will lead to increased contractor pride, better relationships between contractors and WisDOT, a higher quality product, and better construction control and material documentation. In 1999, the Department plans to use the provision on at least two projects in each of the Department's eight districts.

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PTP Research Report
QMP, Concrete Pavement Provision Pilots

I. Introduction

During the summer of 1997, the Wisconsin Department of Transportation (WisDOT) piloted a new provision, "Quality Management Program (QMP), Concrete Pavement" (Appendix A). This is a comprehensive quality assurance provision that includes contractor test results as the primary means of material acceptance. Piloting was performed on five projects by five different contractors in four WisDOT Districts. Piloting entailed performing the selected tasks of the new provision, as a contract change order, in parallel with the original contracted pavement provisions. This allowed for trial use of the sampling, testing documentation, and Quality Control Plan portions of the new provision with contract administration and payment based on the original provisions.

II. Background/History

A committee, consisting of members representing the Wisconsin Concrete Pavement Association (WCPA), Federal Highway Administration (FHWA), WisDOT Districts, and WisDOT Central Office, was formed to develop the new provision. The committee assessed the existing Standard Specifications and QMP provisions (QMP, Aggregate for Concrete Pavement; QMP, Placement of Concrete Pavement) and identified the following objectives for the new provision:

1) Develop methods to improve the quality and uniformity of concrete pavement.
2) Encourage contractor innovation in use of materials and construction methods.
3) Reduce WisDOT field inspection through increased contractor responsibility for material and construction process control.
4) Require additional and more meaningful contractor quality control tests.
5) Revise testing requirements for concrete aggregates produced prior to the approval of a project contract.
6) Address the provisions of the revised FHWA regulation (23 CFR 637B). This enables product acceptance based on contractor testing provided that:
    - Department verification testing is used to validate the quality of the final product,
    - An independent assurance program is used to monitor sampling and testing procedures for contractor quality control and Department verification testing; and
    - Dispute resolution procedures are developed.

III. Purpose

The purpose of this study was to review and analyze the new QMP, Concrete Pavement provision by piloting it on five WisDOT projects.

The parallel piloting of the provision allowed for:

A) A low risk introduction of the provision to the pavement industry and the districts.

B) Reviews by field personnel of the new provision's sampling and testing procedures and protocols, including:
- methods,
- specified limits,
- frequencies and intervals,
- locations, and
- documentation.

C) Determination of where further development or refinement of the provision is necessary.

D) Development of a WisDOT database to store and analyze collected data.

Piloting of this provision provided data and information to determine whether this type of quality management program is effective for concrete paving. The data and information collected was used to refine the provision for optimum performance and administration. In addition, cost data related to the requirements introduced with the provision were collected and compared to the benefits received.

IV. Pilot Project Descriptions

The provision was piloted on five projects in 1997. For each project, the provision was used in parallel to the concrete pavement specifications contained in the original contract. Each project included the QMP, Aggregate for Concrete Pavement provision; and the WisDOT Standard Specifications; two projects included the QMP, Placement of Concrete Pavement provision.

The following table gives information regarding the use and cost of the pilot QMP, Concrete Pavement Provision.

Project ID	Highway	County	Dist.	Contractor	Quantity (SY)	Unit Cost ($/SY)	Total Cost ($)
1700-01-75	STH 11	Green	D-1	Zignego Company	39,400	0.480	18,910
1517-03-76	USH 10	Winnebago	D-3	Vinton Construction Company	97,400	0.246	23,960
1510-08-73	USH 10	Waupaca	D-4	Trierweiler Construction & Supply Company	137,950	0.263	36,330
1052-08-77&79	STH 29	Clark	D-29	Streu Construction Company	156,460	0.319	49,840
1111-08-79	USH 151	Dodge	D-1	James Cape & Sons Company	69,200	0.270	18,690

V. Test Elements

Elements of the provision that were evaluated with the pilot projects included:

A. A contractor quality control plan;

B. A contractor concrete mix design (not performed with pilot projects);

C. Documentation of QC sampling and testing;

D. Aggregate gradation testing during aggregate production;
E. Aggregate moisture measurement and calculation of the ratio of water to cementitious material;
F. Aggregate testing for material finer than the number 200 sieve during concrete production;
G. Compressive strength cylinder fabrication;
H. Compressive strength cylinder curing;
I. Compressive strength cylinder measurement and pay adjustment;
J. Air content measurements;
K. Fresh concrete temperature measurements;
L. Slump measurements;
M. Thickness determination by contractor probing of the freshly placed concrete;
N. Profilograph measurements with a 0.01 mm blanking band;
O. Provisions for repair of cracked newly constructed pavement;
P. Department Verification Testing;
Q. Department Independent Assurance review;
R. A dispute resolution process;
S. Incentive bid items;
T. Cost for use of the provision;
U. Staffing needs for the provision.

VI. Benefits

During development, it was anticipated that this new provision would significantly change the way WisDOT conducts business on concrete paving projects by reducing Department inspection time, and enhancing the performance of concrete pavements through improved contractor process control, increased use of innovative technologies, and improved knowledge of construction operations and pavement characteristics. Once established, this provision will be used on most large, rural mainline, concrete pavement projects administered by WisDOT.

VII. Results

Members of the provision development committee conducted discussions with field staff before, during, and after construction of the pilot projects. Feedback was solicited from project engineers and inspectors, contractors, and testing technicians. The provision was refined for use in the 1999 construction season based on information obtained from these discussions.

The remainder of this section provides a description of the provision's elements that were piloted, review comments from those involved with the pilots, and the associated planned changes for the provision.

A. Quality Control Plan Requirements

The provision requires the contractor to submit a written Quality Control Plan prior to construction. The intention of this plan is to detail the contractor's material and construction control processes.

The Quality Control Plans produced for these pilot projects varied in content. Some contractors disagreed with the information requested for the plan. They felt that some of the information was proprietary or did not contribute to the quality of the product. Also, some felt uncomfortable with the possible risk associated with resolving a project problem differently than as described in their plan. Thus, some plans were more elaborate than others. The Department's opinion of the plans that were written for the pilot projects was that some of the contractor charges were excessive for producing the less detailed plans.

Because of the concerns with the Quality Control Plan requirements and the broad range of plans developed for the pilots, the committee and industry representatives agreed to re-evaluate and adjust the Quality Control Plan requirements and provide more plan development guidance.

B. Mix Design

The provision requires a contractor mix design; however, this portion of the provision was not performed with the pilot projects. This section was discussed at the review meetings.

Additional Department support to this section will include the generation of forms for mix design development, and submittal.

C. Documentation

For the pilot projects, the Department developed and provided data recording forms. Also, Microsoft Excel spreadsheets were created and made available to perform calculations electronically. Most contractors and consultants used the provided data recording forms. One consultant used the spreadsheets.

Recommendations resulting from the pilot projects included:

1) Provide guidelines for filling out forms and instructions for performing calculations.
2) Eliminate redundancy in data recording by:
    - Creating a common lot size.
    - Developing a single data recording spreadsheet for all required tests.

D. Aggregate Gradation Testing

The aggregate sampling and gradation testing requirements of this provision are similar to the established "QMP, Aggregates for Concrete Pavement" provision. Since, the established provision was included with each of the five pilot project contracts, it was not necessary to pilot this portion of the new provision.

The new provision allows use of aggregate that was produced and quality control tested prior to the contract. Wear and soundness testing will continue to be performed by the Department.

E. Water - Cementitious Ratio Calculation

There was a strong desire by the Specification Development Committee to accept material based on the water to cementitious material ratio (W/Cm). The committee; however, agreed that there is no reliable method for measuring the W/Cm ratio of batched material precisely enough to enable administration of a pay adjustment on this property. Therefore; the committee decided to measure the W/Cm ratio with this provision, but wait for the development of a more reliable method of measurement before basing material acceptance on this feature. The W/Cm ratio information collected with the use of this provision will be included in a Departmental database. A future analysis should include an assessment of the variability in the W/Cm and its correlation to strength, quantity of aggregate finer than the No. 200 sieve, and temperature of the concrete.

The pilot studies showed that further instructions and examples are necessary to enable the testing technicians to gain a more thorough understanding of the W/Cm ratio calculations and concept. The calculations for W/Cm ratio are somewhat complicated. Problems were encountered in calculating the aggregate moisture content, using the correct cementitious and/or water content in the calculations, and correctly calculating the W/Cm ratio. Also, one project was constructed using a dry batch plant and mobile mixing trucks. Water was being added to the material at the paving site without being recorded. This lead to incorrect calculations of the W/Cm ratio. The W/Cm ratio data from the pilot projects are summarized in Appendix B.

Automated plant recordation of material quantities will be required with further use of the provision. This will help in achieving a more accurate recording of the W/Cm ratio.

F. Aggregate Testing for Material Finer Than the #200 Sieve

The new provision requires the measurement of aggregate material finer than the number 200 sieve (P200) during the production of concrete pavement.

Following the piloting of the provision, many of the contractor, Department and consultant representatives mentioned that they thought that the measurement of P200 during concrete production was unnecessary. The pilot projects that had a clean hard aggregate resulted in a consistent measure of fine material. Also, for projects where the aggregate was not moved from the original stockpile, the results of this testing was similar to the production results. Agreement was reached to change the provision language to allow for the frequency of this testing to be reduced, if the content of the P200 material is below the warning limit for two consecutive four point moving average points. This change allows the engineer to reduce testing frequency to once per five days of concrete production.

There was discussion in regards to the usefulness of this testing and the thought that it is being collected too late in the process to enable adjusting the material. This will be addressed in the future after further use of the provision.

The P200 data collected during concrete production from the pilot projects are summarized in Appendix B.

G. Compressive Strength Cylinder Fabrication

The provision requires the casting of compressive strength cylinders for every sublot of concrete placed. A sublot is defined as a maximum of 500 cubic yards of material placed.

Generally, the required frequency and methods of compressive strength cylinder fabrication for QC testing were agreeable to the contractor, consultant, and district representatives. Contractors; however, expressed concern over what to do if a required test cylinder was damaged or for some reason a compressive strength test result was flawed.

At the conclusion of the pilot projects, agreement was reached to allow, at the contractor's option, the casting of a third contractor quality control test cylinder per sublot. The averaged strength of two cylinders will continue to be used to represent the strength of the material in the sublot. The intention of the third cylinder is for substitution of a flawed test or cylinder. Breakage of the third cylinder should occur only if the ratio of the failure strength between the first and second cylinder is greater than ten percent. The strength for the sublot shall then be represented by the average strength of the third cylinder and the other cylinder that is closest to it in strength.

Along with the new provision, the Department adopted the policy to allow consolidation of concrete cylinder material, with a slump of 3 inches or less, by vibration or rodding. This follows the AASHTO Test Method T23. Consolidation of cylinders by vibration had not been used in the past by Wisconsin. Future evaluation of the QMP provision will be to track how the compressive strength results from these two methods compare.

H. Compressive Strength Cylinder Curing

The provision requires the compressive strength cylinders to be field cured for the first 24 hours between the temperatures of 60 and 80F. Following the field cure, the cylinders are transported to a laboratory for curing in accordance with AASHTO T23 for the remainder of the 28 day cure period prior to strength testing.

Some district representatives disagreed with the cylinder field curing conditions required by the provision. Their opinion was that the cylinders should be cured under the same conditions as the concrete pavement. There were two reasons why the committee chose to limit field curing temperatures of the cylinders:

1) With a non-covered slab, it would be very difficult and expensive to simulate slab curing conditions in the compressive strength cylinders; and

2) The intention of the provision is to measure the quality of the concrete produced. Compressive strength cylinder curing between the temperatures of 60 and 80F is the recognized standard for assessing the strength of concrete.

Various types of field curing containers were used with the pilot projects. These included curing:

1) In a white five gallon bucket filled with water with and without a lid and changing cooling water on a regular basis;
2) Covered by a cardboard box and cooling with ice, when necessary; and
3) In a styrofoam cooler and cooling with ice, when necessary.

All methods worked under the conditions they were used except for the white bucket with a lid and water. This method was used on days when air temperatures exceeded 85F. It resulted in the temperature of the specimens exceeding the specification limit of 80F. This was remedied by removing the lid from the buckets and changing the water often to keep the specimen temperatures down. This was effective.

In high temperatures the styrofoam coolers were most effective. They worked well in maintaining the desired temperatures; were stackable, inexpensive, light, and provided ample space for ice and water.

I. Compressive Strength Measurement and Pay Adjustment

The provision's incentive/disincentive strength pay adjustment is based on the distribution of the compressive strength cylinder test results for a lot. Superior strengths earn incentives, marginal strengths receive disincentives, and low strengths are subject to removal and replacement of the represented material. Strength limits are based on an engineering analysis that defines the acceptable quality level (AQL) and the rejectable quality level (RQL). These levels, respectively, define how good the strength has to be to meet the design criteria and how bad it can get before rejection is considered. The acceptable and rejectable strength is defined in terms of its magnitude (average) and level of variability(standard deviation). These strength levels are linked to values used in the design of pavement thickness and are supported by performance in the field. Appendix C describes the method used to determine the compressive strength AQL and RQL requirements of this provision.

The provision was written for an incentive/disincentive for strength of $0.33 per square yard and -$1.66 per square yard, respectively. The pay adjustments are based on unit prices rather than on a percentage of the contract price. This method was chosen to make it easier for the designer to estimate costs in advance of the project letting and easier for the construction engineer to administer the pay adjustments. Use of this method, however, will require periodic review to account for inflation.

Appendix D summarizes the compressive strength results for the pilot projects. If the incentive/disincentive provision had been administered on these projects of the 35 strength lots; 23 would have received a bonus, 10 would have received a penalty, and 2 would have received no

adjustment. All the penalty lots resulted on two projects, and the highest strengths resulted on the three other projects.

Based on these results, in discussion following the pilots, industry members mentioned a concern with the associated risk of the disincentive. They accepted the strength limits, but asked to reduce the penalty limits. The risk concern was due to not having tracked strength histories, and with the strengths achieved with:

1. weak aggregates in certain geographical areas of the state; and
2. the recent allowance of new mix designs and the use of slag.

The Department agreed to lower the disincentive limit to -$0.66 per square yard, with an understanding that the pay table will be reviewed for adjustment on an annual basis to establish meaningful mean and standard deviation pay targets that better balance the contractor risk and value gained by the Department.

J. Air Content

The provision requires air content to be measured by the contractor at the time of cylinder fabrication. These measurements are required to be made from the same sample as the compressive cylinders. Strength bonuses will not be paid on sublot material that has low air content. The specification limits for concrete pavement air content is 7.0% +/-1.5%.

At the start up of one project, the air meter used for the quality control testing and that used for verification testing did not correlate. The difference between the readings of the two meters was resolved during the course of the project. To avoid this problem in the future, the provision will be changed to allow, as a contractor Quality Control Plan option, for the correlation of test equipment prior to paving.

There were no further changes to this portion of the provision that resulted from the pilot projects. The air content data collected from the pilot project's is summarized in Appendix B.

K. Temperature

The provision requires concrete temperature to be measured at the time of cylinder fabrication. These measurements are required to be made from the same sample as the compressive strength cylinders. This data will be entered into the Department's data base and used to evaluate possible correlation to product quality. The concrete temperature data collected from the pilot projects is summarized in Appendix B.

There were no changes made to this portion of the provision as a result of the pilot projects.

L. Slump

For this provision, slump will not be required for slipform paving except when requested by the engineer.

There were no changes made to this portion of the provision as a result of the pilot projects.

M. Pavement Thickness Measurement by Probing

The provision was written such that a series of two transverse probings per lane will be performed for each 250 foot longitudinal distance. In discussion following the pilot projects, there was concern that the probes could be biased if they were taken routinely at a paving stake. It was therefore agreed that longitudinal probings would be conducted at a random location for each section. This method will be reviewed for possible adjustment on an annual basis.

The pilot projects were also cored for thickness measurements. The cores correlated well with the probe measurements. The project engineer on each project was satisfied with the method and results of measuring thickness by probing.

The disincentive pay adjustment table form the Standard Specifications was rewritten with this provision. The provision table allowed for an increase in the allowable deficiency, from 1/4 inch to 3/8 inch, in pavement thickness prior to the first pay deduction. The revised pay table was accepted by both the WisDOT districts and the industry contractors.

N. Profilograph

The current WisDOT Standard Specification for Profilograph uses a 0.2 inch blanking band. WisDOT also has an established incentive/disincentive pay adjustment special provision for profilograph. District use of this pay adjustment special provision has steadily declined. It has been felt that the bonus in this provision is too easy to achieve; and periodically, a pavement that meets the requirement for bonus pay does not result in an exceptionally smooth riding pavement.

The new QMP, Concrete Pavement provision incorporates the use of a zero blanking band (0.01 inch) with a refined incentive/disincentive pay adjustment. The intent of the zero blanking band is to eliminate bonus payment for pavements that result in a high frequency vibrating ride that could be masked by the 0.2 inch blanking band. This concept was adopted from field tests performed by the state of Kansas.

Upon review of data collected from the pilot projects, the contractors had concerns with the pay limits of the proposed incentive/disincentive pay table. Comparison of the 0.2 inch blanking band data and the zero blanking band data indicated that the new pay table was much more restrictive than the former WisDOT provision. The proposed zero pay adjustment range required much better rides than the current WisDOT provision. Through analysis of the data (Appendix E), the Department representatives suggested adjusting the limits of the pay table to better reflect what is considered a good

riding pavement in Wisconsin. This reduction placed the disincentive portion of the table at the same level of the previous WisDOT special provision, and changed the incentive portion of the table to levels that the Department felt were worth bonus pay without being extraordinarily difficult to achieve.

The revised pay table follows:

Profile Index; Zero (0.01 inch) Blanking Band (in/mile)	Percent Pay Adjustment
less than 20	105%
20 to less than 25	103%
25 to less than 45	100%
45 to less than 50	98%
50 and greater	92%

Further, the contractors were not yet comfortable with the zero blanking band for determination of areas of corrective work by diamond grinding. It was therefore agreed, that if profile indices surpassed the corrective action levels of the zero blanking band table (45 inches/mile and greater), the data would be re-evaluated with the 0.2 inch blanking band to determine areas of grinding. Corrective work will then be performed to reduce the 0.2 inch blanking band profile index to 10 inches per mile as in the existing WisDOT Standard Specification. As the contractors and Department become more comfortable with the zero blanking band, the corrective action requirements will evolve to be based on the zero blanking band.

These agreements were reached with an understanding that the profilograph provision will be reviewed for possible adjustment on an annual basis. Future analysis should include correlating new construction zero blanking band profilograph data to the 0.2 inch blanking band data. Also, analysis will include comparison with historical International Roughness Index (IRI) data to determine if smoother new construction leads to a longer lasting pavement.

O. Cracking Provision

The new QMP provision addresses cracking of the newly constructed pavement. If a crack occurs within 3.3 feet of a transverse joint prior to opening the pavement to traffic, the provision requires the contractor to repair the joint by removal and replacement of the affected pavement at the contractor's expense. If a crack occurs following opening to traffic or a crack occurs greater than 3.3 feet from a transverse joint prior to opening to traffic then the cost for repair will be shared equally by the department and the contractor.

After discussing the cracking provision with the industry representatives, it was agreed to use this portion of the provision provided that:

1. The maximum cost shared by the DOT for repair be increased from two times to three times the cost of the pavement contained within the cracked panel, at the contract unit price; and
2. The maximum joint spacing meets the most current WisDOT recommendations of 18 feet if the pavement thickness is 9 inches or greater; or 15 feet if the pavement thickness is less than 9 inches.

To help determine methods of repair, the WisDOT Pavement Management Section is preparing guidelines for acceptable crack repair techniques, and WCPA offered to provide a training program on concrete repair techniques for presentation to each of the Department's District Offices.

District response to this portion of the provision was positive. Where no guidance was present in the past, the provision provides guidance for negotiating repair of cracked pavements. A policy was implemented in 1998 for the crack repair guidance to be used on all newly constructed concrete pavements in Wisconsin.

P. Verification

The district representatives agreed with the provision's level of verification testing. Future revisions will include clarification as to when increased verification sampling and testing should be performed to check borderline material or construction.

There were no changes made to this portion of the provision as a result of the pilot projects.

Q. Independent Assurance Review

With the new provision, the Department's Independent Assurance Program was redefined to meet the new federal regulations. This added the new task for the independent assurance program to review contractor sampling and testing procedures, in addition to Department sampling and testing procedures.

R. Dispute Resolution

There were no disputes concerning the pilot provision on any of the projects. It was agreed to add language to the provision to identify the creation of a Conflict Resolution Team to resolve disputes. A Specification Development Committee member will be made part of the Conflict Resolution Team, if there are problems with interpretation of the provision.

S. Incentive Bid Items

For bidding, incentive payment bid items will be included with the contracts when the this provision is used. The incentive payment items will have a fixed cost of 80% of the maximum attainable incentive. This will enable the anticipated profilograph and compressive strength incentives to be part of the bid price rather than having to pay for them by writing a contract change order.

T. Cost

The cost for piloting this provision, through construction change orders, on the five projects ranged from $0.246 to $0.480 per square yard. The cost for each project is reported in the table of Section IV of this report.

The Department estimates these costs to be high because:

1) The pilots were added to the projects through construction change order, thus there was no competition to assure a fair market price.
2) The incentive/disincentives pay adjustments were not implemented. These are anticipated, with time, to lower the price of the QMP because the contractors will anticipate receipt of incentive and start to factor bonuses into their bid.
3) The quality control plan was required for the first time. As this specification is used further, a contracting company will establish a general plan and use this from one project to another with slight variation. This will allow for reduced plan preparation time and cost.
4) Some of these projects used the provision on a smaller portion of the project than it will typically be used. This led to higher unit prices.

For the use of this provision in a contract for 1999, the Department estimates the initial cost to be $0.25 per square yard.

U. Staffing

Each contractor hired a consultant to perform the QC sampling and testing for these pilot projects. Some of the consultants staffed the QC sampling and testing work for this provision using one technician. This proved to be inadequate. Through a long work day, the required standard testing of the provision was accomplished, but it did not provide for timely test results. If a process were changed and increased testing was required to evaluate the effect on the material, a single technician would have difficulty in providing this service.

The consultant staffs estimated that for the majority of the time, during paving operations, one and a half persons are needed to perform and document, in a timely and productive manner, the requirements of this provision. The Department was assured that adequate staffing will be provided when the provision is used in the future.

VIII. Further Development

Remaining work for finalization of the provision includes:

1. Further review the WisDOT Standard Specifications to determine if any further deletions or changes of the standard specifications or QMP provision are necessary to better unify the two documents.
2. Refine the electronic data forms and spread sheets and prepare instructions for their use.

3. Develop a WisDOT database for storage and analysis of the collected data and investigate linking that database to the WisDOT Pavement Management System.
4. Expand the University of Wisconsin - Platteville, Highway Technician Certification Program to accommodate the new sampling and testing procedures introduced with the new provision

IX. Summary, Conclusion, Recommendations

At the conclusion of the pilot projects, the Department project engineers agreed with the Provision Development Committee that a reduction in inspection time may result from the use of this provision; however, some of the hours saved will be needed by staff to review, analyze, and accept the test data. This work will need to be performed by a person who is knowledgeable about concrete pavement; however, much of this review time does not have to be performed concurrently with the construction operations. The project engineers agreed that the provision will lead to increased contractor pride, better relationships between contractors and WisDOT, a higher quality product, and better construction control, and material documentation.

In 1999, the Department plans to use the provision on at least two projects in each district. The provision will be the contracted specification for the projects. This will allow for analysis of the resulting material's uniformity and quality.

The provision will be championed by the WisDOT Bureau of Highway Construction, Standards Development, and Product Quality Sections; and FHWA - Wisconsin Division. WCPA will provide technical assistance to the contractors. The University of Wisconsin - Platteville will assist in developing and providing the corresponding concrete technician certification program necessary to teach contractor, Department and consultant personnel the sampling and testing methods required by the provision.

Annually, for the next couple of years, the Concrete Technical Committee will refine the provision to better meet the needs of both the Department and the industry. This will be done by addressing the concerns identified through working with the provision.

X. Appendices

A. Special Provision

Quality Management Program, Concrete Pavement, Item 90410; Quality Management Program, Concrete Pavement Profile Index Incentive, Item 90411; Quality Management Program, Concrete Pavement Compressive Strength Incentive, Item 90412.

CONTENTS

G.2.2.1. QMP, Concrete Pavement Profile Index Incentive, Item 90411.

G.2.3. Disincentive for Concrete Pavement Thickness.

A. General Requirements and Definitions. This work shall be in accordance with the requirements of Section 415, 416 and 501 of the Standard Specifications except as deleted or additionally stipulated herein.

A.1. General Requirements. The contractor shall provide and maintain a Quality Control Program. A quality control program is defined as all activities and documentation of: 1) mix design; 2) production control, placement control and inspection; and 3) sampling, testing, measurement, and correction of materials and in-place concrete pavement.

A.2. Definitions. Contractor Quality Control Test - testing performed by the contractor and used by the Department for product acceptance. The methods and minimum frequencies shall be as specified in this provision.

Contractor Process Control Test - additional contractor testing taken at the contractor's initiative for process control.

Corrective Action - Action typically required on the part of the contractor when the four point moving average is in the warning band or outside the control limits.

Engineer Directed Testing - additional testing performed by the contractor as requested by the engineer.

Verification Testing - independent sampling and testing performed by the Department to validate the quality of the product.

Independent Assurance Testing - separate unbiased testing, performed by the Department, to evaluate the sampling and testing of the quality control and verification technicians; including personnel qualifications, procedures, and equipment.

Companion Samples - samples collected by the quality control or verification technician for testing by the Department.

Control Limits - the maximum and minimum specified limits of the measured material.

Warning Limits - specified high and/or low limits used to indicate that the measured material is approaching an unacceptable condition.

Four Point Moving Average - the average value of the last four consecutive randomly collected quality control test results. Contractor process control test, engineer directed test, verification test, and independent assurance test results shall not be included in the four point moving average.

Warning Bands - the areas between the upper warning and control limits, or the lower control and warning limits.

Pavement Panel - the entire area of concrete pavement contained within two adjacent transverse joints and two adjacent longitudinal joints, an edge of pavement and adjacent longitudinal joint, or two adjacent pavement edges when there is no longitudinal joint.

Qualified Laboratories - a laboratory that meets the laboratory qualification procedure requirements as defined by the Wisconsin Department of Transportation, Bureau of Highway Construction

Procedure Manual - WisDOT Quality Management Program, Guide/Procedure Manual is intended to assist the contractor and the engineer in conducting quality control and verification for construction projects under the WisDOT Quality Management Program. The Procedure Manual may be obtained from the Wisconsin Department of Transportation, Central Office Construction, 3502 Kinsman Blvd., Madison Wisconsin 53704, or call 608-246-3246.

Construction and Materials Manual - guide to establish uniform procedures in the administration, engineering, and inspection of construction projects. The manual may be obtained from the Wisconsin Department of Transportation, Central Office Construction, 4802 Sheboygan Ave., Room 601, P.O. Box 7916, Madison Wisconsin 53707-7916, or call 608-246-3246.

B. Quality Control Program Requirements.

B.1. Quality Control Plan. The contractor shall submit a comprehensive written Quality Control Plan. Construction of the project shall be in accordance with the information described in the plan. The plan shall be submitted to the engineer no later than one week prior to the project's pre-construction meeting. Concrete production shall not begin before the plan has been accepted by the engineer. The plan shall provide, as a **minimum**, the following elements:

B.1.1 An organizational chart including names, telephone numbers, current certifications and/or titles, and roles and responsibilities of all those involved with the quality control program.

B.1.2 The process of communication by which quality control information will be disseminated to the appropriate persons. This shall include a list of recipients, the communication means that will be used, and action time frames.

B.1.3 Preliminary concrete mix design information that includes anticipated producers, manufacturers, and sources of mix materials, and the name and title of the person responsible for developing the mix design.

B.1.4 The locations of the quality control laboratories for mix design, aggregate testing, cylinder curing, concrete testing, and compressive strength testing. A description of the equipment provided for sampling and testing shall be included.

B.1.5 Aggregate information including production and handling operations; how contamination, segregation, and degradation will be minimized; and locations of testing.

B.1.6 Anticipated mix design gradations and limits.

B.1.7 The procedures and methods of delivery, storage and management of all mix materials.

B.1.8 Facilities, procedures, and controls used to produce a mix that is in accordance with the specifications and the mix design.

B.1.9 The equipment, times, and methods to deliver the concrete mix to the paving site and delivery of the material to the paver.

B.1.10 The initial and routine equipment checks and documentation performed on scales, water meters, admixture dispensers; and delivery, paving, surfacing, and curing equipment.

B.1.11 The methods for monitoring and recording the materials used in each batch.

B.1.12 Procedures for documenting the locations of yielding base course and /or subgrade.

B.1.13 The equipment and process for assuring consolidation and finishing of material at headers, tapers, joints.

B.1.14 The equipment and procedures for concrete placement and the methods of controlling the alignment, profile, cross slope, edge slump, and thickness.

B.1.15 The procedures that will be employed to correct problems as they occur.

B.1.16 A description of the methods for finishing, texturing, and curing concrete.

B.1.17 The types, standards, and frequency of production testing. As a minimum:

a) the number of tests performed for aggregate gradations, moisture and fines; air content, temperature, slump, and compressive strength in accordance with Subsection B.7;

b) the procedures for checking and documenting pavement thickness including transverse locations and method of testing;

c) the procedures for checking and documenting pavement surface smoothness;

d) the corrective action procedures for results found to be outside of satisfactory limits for each type of test.

B.1.18 Define how special and fractional units, as described in Subsection B.7.8.3, herein, will be evaluated for pavement thickness.

B.1.19 The report format that will be used to convey, to the Department personnel, quality control test results; including tabulations, and control charts.

B.1.20 Provisions for responding to applicable adverse weather conditions; such as precipitation, and hot and/or cold weather paving.

Changes to the contractor’s Quality Control Plan shall not be made unless accepted by the engineer. The plan shall be updated with the accepted changes as they become effective. A current copy of the plan shall be provided to the engineer and posted in each of the contractor's laboratories prior to concrete mix production and as changes are adopted.

B.2. Personnel Requirements. The contractor shall provide certified technicians to perform the required material sampling, testing and documentation as described herein. Technicians shall be certified as follows:

Required Technician Certification Level	Sampling, Testing and Documentation Required by Provision Section:
Aggregate Technician I or IPP	B.7.2
PCC Technician IA; or PCC Technician I and Aggregate Technician I or IPP	B.7.3 B.7.4.1 - B.7.4.2 B.7.4.5 - B.7.4.7
PCC Technician II	B.5
Concrete Compressive Strength Tester	B.7.4.3 - B.7.4.4
Profilograph Operator I	B.7.9

Certification shall be in accordance with the Department's Highway Technician Certification Program.

B.3. Laboratory Requirements. The contractor shall furnish and maintain laboratories at the locations identified in the Quality Control Plan to be used for material sampling and testing.

Each laboratory shall have a minimum area of 150 square feet and shall be equipped with a telephone, a suitable answering device, a fax machine and a copy machine. The laboratory equipment shall meet the requirements of the test methods herein identified. All laboratories shall be operational prior to the beginning of production.

B.4. Equipment Requirements. The contractor shall furnish the necessary equipment and supplies for performing quality control testing. The engineer shall be allowed to inspect the measuring and testing devices to confirm both calibration and condition. The contractor shall calibrate all testing equipment in accordance with the Procedure Manual and shall maintain a record of calibration results at the laboratory.

B.5. Concrete Mix Design. Subsections 501.3.6.3.6, 501.3.6.4.5, 501.4.1.2, 501.5.1, 501.5.2, and 501.5.3 of the Standard Specifications are deleted in their entirety. The maximum limit for the percentage of material passing the 75 micron sieve is deleted from Subsections 501.3.6.3.3 and 501.3.6.4.3 of the Standard Specifications.

B.5.1. Submittal and Review Procedures. At least five (5) working days prior to the start of concrete production, the contractor shall submit to the engineer two copies of a Concrete Pavement Mix Design Report. The mix design shall be developed by a certified PCC Technician II of a qualified laboratory in accordance with Subsection B.5.4, herein. The mix design cover sheet shall include signature blocks for both the contractor mix designer and the engineer. Prior to the engineer's review, the mix designer shall sign and date each copy attesting that all information in the report is accurate and true. The engineer will review, comment, sign

and date each copy of the report. The engineer's signature will verify that the engineer had the opportunity to review the mix design, to check that it meets the concrete mix requirements and to comment. One original signed copy will be kept by the engineer. The other copy will be returned to the contractor, within five working days of receiving the report.

B.5.2. Documentation. The mix design documentation shall ensure that the materials used are in accordance with all the requirements described in Subsection 501.3 of the Standard Specifications unless modified herein, or waived by the engineer. The documentation for the original mix designs shall include:

a. Development Information - test dates, the name and location of the laboratory used to develop the mix design;

b. Mix Properties - material proportions, batch weights, 28-day compressive strength, concrete air content, ratio of water to cementitious material;

c. Material Information - type, brand, source;

d. Aggregate Information - air correction factor, proposed gradation control limits, absorption, specific gravities, wear and soundness test results.

B.5.3. Mix Design Physical Requirements. A minimum of five pairs of tests cylinders shall be used to demonstrate the compressive strength of a mix design. Reported strengths may be obtained by either laboratory testing or previous field test data which utilized a similar mix design. The average compressive strength achieved, in 28 days or less, by the five pairs of cylinders shall be 4200 psi or greater.

The minimum cement content shall be 565 lbs/cy. Fly ash may be used as a partial replacement for Portland cement at a replacement ratio of 1.3 lbs of fly ash per 1.0 lbs of cement up to a maximum fly ash content of 30% of total cementitious material. Alternatively, slag may be used as a partial replacement for cement at a replacement ratio of 1.0 lb. of slag per 1.0 lb. of cement up to a maximum cement replacement of 50%. Fly ash and slag shall conform, respectively, to Subsections 501.3.7 and 501.3.8 of the Standard Specifications. For all mix designs which include fly ash or slag, the date restrictions for Grade A-FA concrete as described in Subsection 501.4.3 of the Standard Specifications shall apply.

For mix design, the ratio of water to total cementitious material, including free surface moisture on the aggregates but not including moisture absorbed by the aggregates shall not be more than 0.42 by weight.

Aggregate size restrictions are as follows:

a. One hundred percent of the aggregate shall pass the 2 inch sieve.

b. The percent of total aggregate finer than the No. 200 sieve shall not exceed 2.3 percent, by weight.

c. The total aggregate finer than the No. 4 sieve shall not exceed 42 percent, by weight; except, if the coarse aggregate is completely composed of crushed stone and/or recycled concrete then, the total aggregate finer than No. 4 sieve shall not exceed 47 percent, by weight.

Chloride based accelerators are prohibited from use in mixes for all new construction.

The adjustment of dosage rates of concrete admixtures will be permitted without requiring a new mix design.

B.5.4. Development Facility. Mix Designs shall be developed by a qualified laboratory. The contractor shall submit to the engineer, prior to the start of mix design development, written documentation which contains the following laboratory information:

a. Qualifications of personnel; laboratory manager, supervising technician, and testing technicians.

b. A statement that the equipment used in developing the mix design is in calibration.

c. A statement that each test specified in developing the mix design is offered in the scope of the laboratory's services.

d. A copy of the laboratory's quality control system.

B.5.5. Mix Changes. Modifications to a mix design shall be prepared, and submitted to the engineer for review, prior to use. Modifications, that require review, include changes in: 1) the source of any material, 2) the amounts of cementitious materials, 3) the adjustment of fine to total aggregate greater than ±3 percent by weight, or 4) the addition or deletion of admixtures.

When required or permitted, Air Entrained High Early Strength Concrete shall be prepared with Type III cement. In lieu of such preparation, a minimum of an additional 95 lbs of cement may be added per cubic yard of concrete to the accepted contractor’s concrete mix design. The High Early Strength material shall be excluded from the contractor’s tests for compressive strength pay adjustment, but shall be included with all other quality control tests.`

B.6. Process Control Documentation

B.6.1. Control Charts. The contractor shall maintain linear control charts when required by the test reporting procedures herein.

Control charts shall be posted in a location satisfactory to the engineer and shall be brought up to date daily. The control charts shall include the project number, the test number, each test element, the applicable warning and control limits, the contractor's individual test results, the moving average of the last four data points, and the engineer's verification and independent assurance test data points. The contractor shall use the control charts as part of a process control system for identifying potential problems and assignable causes.

The contractor's test data shall be shown in black and the four point moving average in red. The engineer's verification data shall be plotted as blue circles and the independent assurance data plotted as blue squares. The warning limits shall be drawn with a dashed green line and the control limits with a dashed red line. Other means of chart plotting may be used when approved by the engineer. Control chart legends shall be consistent throughout a project.

B.6.2. Records. The contractor shall be responsible for daily documentation of all observations, records of inspection, adjustments to the mix, and test results. The original testing records and control charts shall be provided to the engineer in a neat and orderly manner within ten working days after completion of concrete production.

B.7. Required Quality Control Testing.

B.7.1. General. The contractor shall perform all quality control tests necessary to control the production and construction processes applicable to this Special Provision and as set forth in the Quality Control Plan. The contractor shall perform the following tests at a frequency not less than that defined herein:

Aggregate Gradations	AASHTO T-11* & T-27*
Aggregate materials finer than the No. 200 sieve	AASHTO T 11
Aggregate Moisture	AASHTO T 255*
Air Content	AASHTO T 152*
Slump	AASHTO T 119*
Temperature	ASTM C 1064
Tolerance in Pavement Thickness	AASHTO T 148, T24 & C&M Manual 13.20.9
Profilograph	As Described Herein
Strength	AASHTO T 22, T 23*, T 141*

*As modified by the Department in the WisDOT Construction and Materials Manual (C&M Manual), Chapter 13.

B.7.2. Aggregate Gradation Testing.

B.7.2.1. Sampling and Testing Requirements. The contractor shall randomly sample and test the individual aggregate gradations according to AASHTO T 11, Materials Finer Than 75 micron (No. 200) Sieve in Mineral Aggregate by Washing, as modified by the

Department, and AASHTO T 27, Sieve Analysis of Fine and Coarse Aggregates, as modified by the Department. All sampling, testing and documentation shall be performed by a certified Aggregate Technician I or IPP. Testing should be performed as the aggregate is being produced. If the aggregate material was created previous to the contract, and aggregate production records are not available or not acceptable to the engineer, then sampling and testing shall be performed as the material is being used at the concrete production site. Sampling and testing shall be at a frequency not less than that listed below.

Daily Aggregate Production, or Use Rate (Tons)	Minimum Testing Frequency for Each Aggregate Stockpile (Number of Tests Per Day)
0 -1000	1
1000-2000	2
2000+	3

Only the results of the randomly selected samples for quality control tests shall be included in determining the four point moving average points.

Each sample of the fine aggregate shall be washed. The first four samples of each of the coarse aggregates shall be washed. If the material finer than the No. 200 sieve of the coarse aggregate is less than the warning limit, at least, every tenth sample of each of the coarse aggregates shall be washed. If the material finer than the No. 200 sieve of the coarse aggregate is greater than or equal to the warning limit, each sample of the coarse aggregate shall be washed until four consecutive tests are less then the warning limit.

Control limits for aggregate sieve sizes shall be as identified by the contractor in the project's Quality Control Plan. The aggregate gradation warning limits shall lie inside the upper and lower control limit values by one percentage point for all sieves except as follows:

(1) The upper warning limit on the material finer than the No. 100 sieve and No. 200 sieve shall be inside the control limit value by 0.5 percentage point.

(2) For the sieves which allow 100 percent of the material passing, there is no upper warning limit. For the sieves which allow zero percent of the material passing, there is no lower warning limit.

B.7.2.2. Documentation. Standardized linear control charts, as described in Subsection B.6.1, shall be maintained by the contractor at the laboratory. A set of control charts shall be provided for each aggregate stockpile. A control chart shall be maintained for each control sieve that pertains to the type of material being produced. Test results obtained by the contractor shall be recorded on the control charts the same day the tests are conducted. Additional documentation shall be in accordance with Subsection B.6.2, herein.

B.7.2.3. Corrective Action. When the four point moving average value approaches a warning limit, the contractor shall consider corrective action. The corrective action, if any, shall be documented and become part of the project records.

The contractor shall document whenever a four test moving average exceeds the warning limits. When a second consecutive moving average value exceeds the warning limits, the contractor shall take corrective action. Corrective action shall continue until two consecutive average points are within the warning limits.

The contractor shall notify the engineer whenever an individual test value exceeds a control limit. The material shall be considered unacceptable when the individual test result exceeds the control limit. The quantity of unacceptable material shall include the material of the first test result exceeding the control limit, continuing to but not including the material from the first subsequent test result that is within the control limits. Action regarding the disposition for unacceptable material shall be in accordance with Subsection 106.5 of the Standard Specifications.

B.7.3. Aggregate Sampling and Testing During Concrete Production.

All sampling, testing and documentation shall be performed by a certified PCC Technician IA or a person certified as a PCC Technician I and Aggregate Technician I or IPP.

B.7.3.1. Aggregate Moisture Content. For each day concrete pavement is produced, the moisture content of the fine and course aggregates shall be measured and recorded. Based on eight hours of daily production, at least one random sample shall be collected and tested during each the first and third quarter of the day, and as mix conditions change. Measurements shall be made in accordance with AASHTO T 255, Total Moisture Content of Aggregate by Drying. The tests may be performed in conjunction with and with the same sample as the AASHTO T 11 tests required in Subsection B.7.3.2, herein. Each time aggregate moisture measurements are made, the ratio of water to cementitious material shall be calculated and recorded. The time of sampling and the water cementitious ratio shall be recorded on the combined gradation control chart for materials finer than the No. 200 sieve, as described in Subsection B.7.3.2, herein. The ratio of water to cementitious material shall be calculated in accordance with the Procedure Manual.

Whenever the moisture content of the fine or coarse aggregate changes by more than 0.5 percent, batch weights shall be adjusted.

B.7.3.2. Material Finer than the No. 200 Sieve.

B.7.3.2.1. Sampling and Testing. For each day concrete pavement is produced, the percent of material finer than the No. 200 sieve within the fine and coarse aggregates shall be measured and recorded. Tests shall be performed in accordance with AASHTO T 11 as modified by the Department. Initially at least one random sample shall be collected and tested during each the first and third quarter of the day, and as mix conditions change.

When two consecutive four point moving average points are below the warning limit, this testing can be reduced as approved by the engineer. In no case shall testing be reduced to a frequency of less than once per five days of concrete production. When an individual test exceeds the warning limit, testing twice per day shall resume.

Test documentation shall be in accordance with Subsections B.6.1, B.7.2.1, and B.7.2.2, herein, by developing a combined gradation control chart for material finer than the No. 200 sieve. The control limits shall be as defined in the Mix Design report. Only the results of the randomly selected samples for quality control tests shall be included in determining the four point moving average points.

B.7.3.2.2. Corrective Action. When the four point moving average value approaches a warning limit, the contractor shall consider corrective action. The corrective action, if any, shall be documented and become part of the project records.

The contractor shall notify the engineer whenever a four test moving average exceeds the warning limits. When a second consecutive moving average value exceeds the warning limits, the contractor and engineer shall discuss a course of corrective action. The corrective action shall be performed by the contractor.

If the corrective action improves the property in question such that the new moving average, after four additional individual tests, is within the warning limits, the contractor may continue production. If the correction does not improve the property, and the new moving average stays in the warning band, the contractor shall repeat the steps outlined in the previous paragraph starting with notifying the engineer.

The contractor shall notify the engineer whenever an individual test value exceeds the control limits. The material shall be considered unacceptable when the individual test result exceeds the control limit. The quantity of unacceptable material shall include the material of the first test result exceeding the control limit, continuing to but not including the material from the first subsequent test result that is within the control limits. Action regarding the disposition for unacceptable material shall be in accordance with Subsection 106.5 of the Standard Specifications.

B.7.4. Compressive Strength. Adjustment to the contract price and concrete acceptance will be based on the compressive strength of concrete cylinders.

B.7.4.1. Concrete Sampling. A pay adjustment for compressive strength shall be applied on a lot-by-lot basis. Concrete shall be accepted or rejected on a sublot-by-sublot basis. A pay adjustment lot shall typically consist of the amount of concrete pavement placed during each day's paving. Each lot shall be divided into standard sublots. The standard sublot size shall be defined in the Quality Control Plan, but should not exceed 500 cy. The material from any partial sublot left unsampled at the end of any day will be incorporated into the previous sublot for acceptance purposes. The material from any partial sublot that has been sampled will stand

on its own as a partial sublot for acceptance purposes. No single lot shall contain concrete of more than one mix design, as defined in Subsection B.5.5, or placement technique.

Sampling, testing and documentation of the concrete during production and placement shall be performed by a certified PCC Technician I or IA. One set of two or three 6 inch by 12 inch cylinders shall be taken for each sublot from the plastic concrete delivered to the job site. The number of cylinders cast per sublot shall be chosen by the contractor and stated in the project's Quality Control Plan. Each of the sublot's cylinders shall be cast from the same concrete sample. Random sublot sampling locations shall be determined by the Certified Technician, as described in the Procedure Manual. The concrete shall be sampled and test cylinders cast and cured in accordance with AASHTO T 141 and T 23, respectively. To enable a central casting and curing area for a day's lot, the fresh concrete may be transported from the sample location up to 3/4 miles.

No lot shall be represented by less than four sampled sublots. When less than four random samples are collected in a day, the represented concrete shall be incorporated into the following or previous day's pavement lot.

One set of two or three companion cylinders, for Department testing, shall be fabricated during each day of concrete production from a sublot designated by the engineer. The number of companion cylinders fabricated shall coincide with the number of quality control cylinders cast for that sublot. These cylinders shall be fabricated from the same concrete sample as the contractor's quality control cylinders for the sublot. The contractor shall provide all materials, fabrication, initial curing and handling of these cylinders for up to three days following fabrication.

B.7.4.2. Concrete Cylinder Curing. The contractor shall provide adequate facilities for the initial curing of cylinders. During the 24 hours after molding, the temperature immediately adjacent to the specimens should be maintained in the range of 60 to 80 F, and the loss of moisture from the specimens prevented. Between 24 and 48 hours following fabrication, the specimens shall be transported to a laboratory, qualified by the Department, for standard curing and compressive strength testing. The specimens shall be cured for a total of 28 days prior to compressive strength testing.

B.7.4.3. Compressive Strength Testing. Compressive strength testing and documentation shall be performed by a certified Compressive Strength Tester in a laboratory qualified by the Department. The compressive strength, in pounds per square inch, of each cylindrical concrete specimens shall be determined 28 days following casting, in accordance with the requirements of AASHTO T 22. The compressive strength of each sublot shall be represented by the average compressive strength of two quality control test cylinders, as chosen by the contractor, cast from a single sample. The compressive strength test machine shall automatically record the date, time, rate of loading and maximum load of each strength cylinder. Each cylinder shall be tested to failure. A printout of this information shall accompany the compressive strength documentation for each cylinder cast for the sublot.

The Department reserves the right to periodically observe sampling and testing performed by the contractor, monitor strength testing, and to direct the contractor to make additional test cylinders for testing and evaluation by the State. The additional samples will not be used for determining the pay adjustment for the lot. All test results shall be available to the engineer for review at any time during normal working hours.

B.7.4.4. Payment Adjustment. Pay adjustment for each lot will be based on the compressive strength results of the quality control test cylinders fabricated from each sublot included in the lot. The dollar amount of the pay adjustment, for concrete pavement compressive strength, will be determined in accordance with Subsection G.2.1, herein.

B.7.4.5. Removal and Replacement. The concrete pavement contained in a sublot will be assessed for removal if the contractor's 28-day compressive strength test result, the average strength of the two sublot test cylinders, is less than 2500 psi. Removal assessment shall determine the strength of the in-place pavement based on the compressive strength of cores, removed and tested, by the contractor, in accordance with AASHTO T 24. The final disposition of the represented pavement shall be based on the core strengths and in accordance with Subsection 106.5 of the Standard Specifications.

B.7.5. Air Content. On each day of production the air content of the fresh concrete shall be tested as early and as frequently as possible until the material being produced meets the specifications and the production process is under control. Thereafter, an air content test shall be performed for each compressive strength sublot. Air content tests shall be performed, by a certified PCC Technician I or IA, on concrete taken from the same sample from which the quality control strength cylinders are produced, unless otherwise required. Air content tests shall be performed in accordance with AASHTO T 152 as modified by the Department. The lower and upper control limits for Air Content shall be 5.5% and 8.5%, respectively. The lower warning limit for Air Content shall be 6.0%. There is no upper warning limit.

B.7.5.1. Documentation. A standardized linear control chart, as described in Subsection B.6.1, shall be maintained by the contractor in a fixed location on the project site. All tests shall be recorded and become part of the project records. Only test results of samples selected randomly shall be included as part of the four point running average plotted on the control charts. These shall be plotted the same day the tests are conducted.

Each time an admixture dosage rate is changed, admixture dosage rates, time of day, and air temperature shall be documented on the combined gradation control chart for material finer than the No. 200 sieve, as described in Subsection B.7.3.2.1, herein.

B.7.5.2. Corrective Action. If the result of an individual air content test is in the specified warning band, the air content test frequency shall be increased to one random test per 250 cy of concrete being placed. This coincides with two tests per compressive strength sublot. One of these tests shall be performed from the same concrete sample from which the quality control

strength cylinders are produced. This testing frequency shall continue until an individual test point is above the lower warning limit.

When the four test moving average value approaches the lower warning limit or the upper control limit, the contractor shall consider corrective action.

The contractor shall notify the engineer whenever a four test moving average is less than the lower warning limit. When a second consecutive moving average value exceeds the warning limit, the contractor and engineer shall discuss a course of corrective action. The corrective action shall be performed by the contractor.

If the corrective action improves the property in question such that the new moving average, after four additional individual tests, is within the warning limits, the contractor may continue production. If the correction does not improve the property, and the new moving average stays in the warning band, the contractor shall repeat the steps outlined in the previous paragraph starting with notifying the engineer.

If an individual air content test is outside the control limits, the contractor shall notify the engineer, and perform additional air content tests as often as possible on subsequent loads of material being delivered to the work site until the air content is inside the control limits. The material shall be considered unacceptable when an individual test result exceeds a control limit. The quantity of unacceptable material shall be that material contained within the load of the first test result exceeding the control limit, continuing to but not including the load with the first subsequent test result that is within the control limits. Compensation, rejection, or removal/replacement of unacceptable material shall be in accordance with Subsection 106.5 of the Standard Specifications. In no case shall a compressive strength bonus be paid on the quantity of material determined to be unacceptable.

B.7.6. Concrete Temperature. The concrete temperature shall be measured in accordance with ASTM C 1064, by a certified PCC Technician I or IA, from the same concrete sample from which the quality control strength cylinders are produced. Concrete temperatures shall be recorded on the air content control chart.

B.7.7. Slump. Tests for slump shall be made, in accordance with AASHTO T 119, by a certified PCC Technician I or IA. Slump tests for slipform paving will not be required except when requested by the engineer. Slump testing of concrete used in other placement techniques shall be performed at the same frequency and from the same composite sample as the compressive strength cylinders, or as requested by the engineer. The concrete material shall comply to Subsection 415.5.4 of the Standard Specifications.

B.7.8. Tolerance in Pavement Thickness. Section 415.5.16 of the Standard Specifications shall be deleted and replaced as follows.

B.7.8.1. General. The pavement shall be constructed to the thickness shown on the plans. Acceptance and payment of the pavement will be based on the measured thicknesses.

Contractor probing of the freshly placed concrete will be the primary method for determination of thickness. The required quality control test measurements shall be recorded and will become part of the permanent project record.

Areas with deficient thickness, as defined below, will be determined by coring and accepted and paid for as prescribed in Subsection G.2.3.

B.7.8.2 Definitions. These definitions are used to describe thickness within this provision:

Acceptable	Greater than or equal to the plan thickness minus 1/4 inches.
Marginal	Greater than or equal to the plan thickness minus 1 inch but less than the plan thickness minus 1/4 inches.
Deficient	Less than the plan thickness minus 1 inch.
Measured Thickness	The thickness determined as the average of the quality control measurements taken for a pavement unit.
Final Thickness	The thickness determined after validation, verification, and resolution of disputes for an area of pavement.

B.7.8.3 Pavement Units. Generally, the pavement shall be divided into basic units 250 feet long, measured along the pavement centerline. Fractional units less than 250 feet but greater than or equal to 100 feet long shall be considered a whole basic unit. Fractional units less than 100 feet long shall be included as a part of a contiguous basic unit.

The width of a basic unit shall be one lane, as measured from the pavement edge to the adjacent longitudinal joint; from one longitudinal joint to the next; or between pavement edges where there is no longitudinal joint.

Special units shall be established for areas of fillets, intersections, gaps, ramps and other special areas not included in basic units.

B.7.8.4 Contractor Quality Control Tests.

B.7.8.4.1 General. The measured thickness of a pavement unit shall be determined as:

1. For a basic unit containing no deficient areas, the average of the two required contractor probings made within that unit.

2. For a special unit containing no deficient areas, the average of the measurements made within that unit as agreed upon by the engineer.

3. For units containing deficient areas, the average thickness of the remaining portion of that unit that has not been defined as deficient. This determination shall be based on adjacent required tests and, if agreed upon by the engineer, may include additional measurements provided by the contractor.

In computing the measured thickness for a unit, individual measurements in excess of the plan thickness by more than 1/4 inch shall be considered as the plan thickness plus 1/4 inch.

B.7.8.4.2 Probing. The contractor shall make a series of two probings for each basic unit. Both probings shall be at a single longitudinal location selected at random. Individual probings shall be at transverse locations as defined by the contractor in the Quality Control Plan. The probing locations may be changed as approved or requested by the engineer.

Probing may be used to determine the measured thickness of special units. The contractor shall measure the depth of a special unit at a minimum of two locations as approved by the engineer.

For each type of unit, the engineer will periodically observe the contractor's testing procedure to assure that the test is being performed properly. At the engineer's request, the probing assembly shall be brought to the edge of the pavement for the engineer to validate the accuracy of the measurements recorded by the contractor.

All probing tests shall be conducted as prescribed in Subsection 13.20.9 of the Construction and Materials Manual.

B.7.8.4.3 Alternate Method. An alternate method, agreeable to the engineer, may be employed to determine the measured thickness of special units. The contractor shall measure the depth of a special unit at a minimum of two locations as agreed upon by the engineer. Contractor measurements and a brief description of the method employed shall be recorded and will become part of the permanent project record.

B.7.8.5 Determination of Final Thickness. Payment for concrete pavement thickness will be in accordance Subsection G.2.3, herein.

B.7.8.5.1 Acceptable Areas. When the final thickness of a pavement unit is acceptable, no more measurements are required and that unit will be paid for at the full contract price.

B.7.8.5.2 Marginal Areas. When the final thickness of a pavement unit is marginal, the pay adjustment for that unit will be contingent upon the final thickness of the next unit in that lane. If the location for the next required random probing series is within 125 feet of the first test location, the contractor may select and document a new random location to provide space

for corrective action.

If the final thickness of the next unit is acceptable, then no pay adjustments will be assessed for either unit. If the final thickness of the next unit is not acceptable, pay will be adjusted for both units. Pay adjustment will continue for each succeeding unit until a unit with acceptable final thickness is produced.

B.7.8.5.3 Deficient Areas. Pavement will be considered deficient if an individual required contractor probe measurement is deficient, or the outcome of an investigation of a discrepancy between contractor and Department test results indicates a deficient final thickness.

The engineer will take additional measurements by coring of the hardened concrete to determine the extent of this deficient area. Cores will be taken at points approximately 20 feet in each direction of the deficient measurement on a line generally parallel to the centerline or longitudinal axis of the unit. Coring will continue until a core that is not deficient is located in each direction. The limits of the deficient area will be determined, at each end, by lines drawn across the unit of pavement midway between the location of the last two cores.

Core testing will be performed by the engineer as prescribed in AASHTO T 24 and evaluated by the engineer as prescribed in AASHTO T 148. Coring, including filling of the holes with concrete or mortar, shall be paid for by the contractor.

B.7.9. Profilograph. Section 415.5.9.8.2 of the Standard Specifications shall be deleted and replaced as follows.

B.7.9.1. General. In addition to the straightedge tests, as described in Subsection 415.5.9.8.1 of the Standard Specifications, the profiles of the mainline pavement surface shall be established, evaluated and the pavement surface corrected as necessary, so that final surface variations shall not exceed the specifications of Subsection B.7.9.5, herein. Mainline pavement is defined as all pavement other than shoulders, parking lanes, ramps, tapers, acceleration and deceleration lanes, bridge decks, bridge approach slabs, the new pavement surface within 50 feet of bridge deck approach slabs, existing pavement joined by the new pavement, the new pavement surface within 50 feet of existing pavement, and concrete gaps shorter than 50 feet in length.

B.7.9.2. Profilograph Equipment. A California Type Profilograph shall be used to measure the mainline pavement surface profiles. The profilograph shall be furnished by the contractor and operated by contractor personnel. It shall be a 25 foot wheel base microprocessor controlled instrument with data recording and printing capabilities. The instrumentation shall provide reduction of measured profile data and generate graphic reports containing scaled reproduction of the measured profile with stationing, deviation information and documentation points. It shall be capable of producing a profile index using both a 0.01 inch and 0.2 inch width blanking band and identifying locations that require correction.

The equipment shall be maintained in full working order. Equipment not maintained in full working order or not able to generate reproducible test results shall be removed from the project and repaired or replaced.

The profilograph shall be on the project, calibrated and ready for operation before mainline paving work begins. If the profilograph becomes inoperable or is removed from service for repair, it shall be replaced with a profilograph in full working order, calibrated and ready for operation before mainline paving work begins the following day.

The engineer shall be given timely notice and the opportunity to observe the calibration and operation of each profilograph used on the project.

B.7.9.3. Profilograph Testing and Operation. Pavement profiles shall be taken 3 feet from and parallel to each edge of pavement placed at a 12 foot width or less. When pavement is placed at a greater width than 12 feet, the profile shall be taken in the areas of the wheel tracks described as follows: 3 feet from and parallel to each edge of the traveled way and 3 feet from and parallel to the location of each planned longitudinal joint on each side of the joint.

The profilograph shall be operated at a speed of no more than 3 miles/h.

The mainline pavement surface shall be tested with the profilograph as soon as the concrete has cured sufficiently to allow testing. Membrane curing damaged during the testing operation shall be repaired by the contractor at the contractor's expense.

B.7.9.4. Profilograph Data Reduction. For each standard and partial length section of finished pavement surface, the contractor shall determine a profile index (inches/mile), using a 0.01 inch width blanking band. A pavement section shall be a continuous area of pavement, one lane wide. A standard section length shall be 0.1 miles. Each day's paving shall be subdivided into standard segments. Partial end sections may be avoided by including the profilograph measurement of these short ends with measurement of contiguous material being placed at a later date. When partial sections do not abut continued new mainline pavement, partial segments shall be treated as an independent segment when they are more than 0.05 miles in length. Partial segments shall be included with a contiguous standard section when they are 0.05 miles or less in length.

A profile index is defined as the average of both profiles taken in a single lane. A profile is the sum of the scallop heights outside a blanking band divided by the length of the pavement segment. A scallop height shall be rounded to the nearest 0.05 inches. A scallop should not be recorded if less than 0.03 inches vertically, and 2 feet longitudinally. Determination of the profile index shall be in accordance with the test method established by the Department.

B.7.9.5. Profilograph Corrective Action. Each individual profilograph trace (not the average of multiple traces) shall be evaluated for corrective measures.

Regardless of the profile index, all high points in excess of 0.4 inches in a length of 25 feet or less shall be corrected by diamond grinding. Following correction, the 0.01 blanking band profile index shall be reestablished.

The average profile index of each section shall be 45 in/mile or less. Sections with profiles that exceed 45 in/mile may be accepted after corrective measures by the contractor have been completed. Corrective work, with the approval of the engineer, shall consist of diamond grinding. To determine areas of diamond grinding, each profilograph trace for the section shall be reestablished using a 0.2 inch blanking band. Correction should consist of grinding the high points that produce scallops that exceed the 0.2 inch blanking band. Correction shall be performed to produce a 0.2 inch blanking band profile index of 10 in/mile or less. Profiles shall be taken, following corrective work, to verify that corrections have produced an acceptable profile index.

If the profile index is more than 50 in/mile before corrective work, the paving operation shall be suspended and will not be allowed to resume until corrective action has been taken by the contractor. Corrective action shall include evaluation of the paving equipment and operation, and any needed adjustment. If paving operations are suspended as a result of the profile index exceeding 50 in/mile, subsequent paving operations shall be tested immediately after corrective action has been made.

If corrections do not produce a mainline pavement surface meeting the smoothness requirements stated above, compensation will be determined in accordance with the provisions of Subsection 105.3 of the Standard Specifications.

A profilograph parameters report, and profile index report shall be provided to the engineer for each test section.

The Department may perform profilograph testing on the pavement surface for monitoring and comparison purposes. In the event of discrepancies in test results between the Department and the contractor, the conflicts shall be resolved as described in Section D, herein.

Pay adjustment for Concrete Pavement based on the initial 0.01 blanking band profile index determined for each 0.1 mile section will be in accordance with Subsection G.2.3, herein.

B.7.10. Pavement Cracking Tolerances

B.7.10.1. Cracks Identified Prior to Opening to Traffic. Prior to the pavement being opened to traffic or seven days following paving, whichever occurs first, the engineer will inspect the pavement for cracking. Opening to traffic is as defined in Subsection 415.5.15 of the Standard Specifications. The engineer's inspection will be documented and a copy of the record will be provided to the contractor. The contractor shall provide the engineer written acceptance of the report prior to opening the pavement to traffic.

Cracks occurring in the pavement within 3.3 feet of a transverse pavement joint shall be repaired by removal and replacement of the affected pavement, unless otherwise approved by the engineer. This repair shall be in accordance with Subsection 416 of the Standard

Specifications and the details shown on the plans for concrete pavement repair. The contractor shall bear all necessary costs of such repair.

For any cracking greater than 3.3 feet from a transverse pavement joint, that the contractor can substantiate the affected panels were constructed in accordance with the plans and specifications, no fault will be assigned. The engineer and contractor shall mutually analyze the deficiency to determine whether repair is necessary, and if so, an appropriate remedial treatment. The cost of these repairs shall be shared equally by the Department and by the contractor up to the Department's maximum contribution as defined in Subsection B.7.10.3.

For any pavement cracking which is determined to have resulted from noncompliance to the specifications or plans, the affected pavement shall be corrected in accordance with Section 105.3 of the Standard Specifications.

B.7.10.2. Cracks Identified After Opening to Traffic. The engineer will conduct a second inspection of the pavement for cracking, prior to the section being opened to public traffic, if previously opened to construction traffic. The engineer will document the inspection and provide a copy of the record to the contractor. The contractor shall provide written acceptance of the report and, if there are cracks, a schedule for repair of the cracks to the engineer prior to opening the pavement to public traffic.

For cracks of which the contractor can substantiate the affected panels were constructed in accordance with the plans and specifications, no fault will be assigned. The engineer and contractor shall mutually analyze the deficiency to determine whether repair is necessary, and if so, an appropriate remedial treatment. The cost of these repairs shall be shared equally by the Department and by the contractor up to the Department's maximum contribution as defined in Subsection B.7.10.3.

For any pavement cracking which is determined to have resulted from noncompliance to the specifications or plans, the affected pavement shall be corrected in accordance with Section 105.3 of the Standard Specifications.

B.7.10.3. Cost Sharing. All remedial work on pavement which requires repair shall be performed prior to opening the pavement to public traffic, whenever feasible. When the contractor elects not to make the necessary repairs prior to opening to public traffic, the entire cost of traffic control shall be the responsibility of the contractor.

The agreed upon cost for repair of the cracked pavement shall include all materials; furnishing all labor, tools, equipment and incidentals excluding traffic control; and the removal and disposal of the existing pavement. The Department's maximum contribution to the agreed upon repair cost shall not exceed three times the contract unit cost of the pavement contained within the cracked panel. If traffic control needs to be reestablished for the repair, the cost shall be independent of the repair cost and shared equally. The cost for traffic control shall be determined using contract unit prices.

C. Department Testing.

C.1. General. The Department will conduct verification testing to validate the quality of the product and independent assurance testing to evaluate sampling and testing. Acceptance and payment will be based on the contractor's quality control tests until it can be shown through the validation, verification, or dispute resolution process that the contractor's test results are in error.

The Department will conduct verification and independent assurance tests on material samples in accordance with Subsections C.2. and C.3. Except for strength tests, the test results will be provided to the contractor within two working days after the sample has been obtained by the Department. The Department will provide to the contractor a listing of names and telephone numbers of the personnel responsible for the verification and independent assurance programs.

C.2. Verification Testing. Verification testing will be performed by an appropriate Certified Technician or an Assistant Certified Technician under the direction of a Certified Technician. Certification will be in accordance with the Department's Highway Technician Certification Program.

Samples will be collected randomly by the Department. The sampling and testing locations will be independent of the contractor's quality control work. In all cases, the verification tests will be conducted in a separate laboratory and with separate equipment from the quality control tests.

Verification Testing will be performed in accordance with the following schedule:

	Testing Frequency Guide*	Sampling Material and Location	Test Method	Alternate Test Methods
Air Content	1 per lot	Plastic Concrete, Ahead or Behind** the Paver	AASHTO T 152 as Modified	Hardened Air Content Testing**, Following Construction
Strength	1 per 5 lots	Cylinders	AASHTO T 22, T 23 & T 141 as Modified	Random Cores**, Following Construction
Pavement Thickness	2 per day	Thickness Probing	Construction & Materials Manual, Subsection 13.20.9	Random Cores, Following Construction

* Frequency of sampling and testing may be increased by the engineer at the start up or as necessary to validate the quality of the materials or reduced based on a history of satisfactory contractor or material performance.

** Evaluation of test results should account for systematic differences in testing methods or sampling locations.

For verification testing for thickness by probing, the engineer will select a longitudinal location at random and designate the transverse positions for a series of two probings in each lane of pavement at that location. The contractor shall perform the probing as prescribed in Subsection 13.20.9 of the Construction and Materials Manual. The engineer will be present and observe both placement of the plates and probing of the freshly placed concrete. The engineer will record the individual measurements and calculate the average thickness for each lane. In computing the average thickness for verification tests, measurements in excess of the plan thickness by more than 1/4 inch will be considered as the plan thickness plus 1/4 inch. The engineer will make available the results of the verification tests to the contractor without delay.

The verification test results will be plotted on the contractor's quality control charts in accordance with Subsection B.6.1. These results will not be included with the four point running average.

When verification test results indicate specification compliance, no further action is required. When test results indicate non-conformance, the discrepancy shall be investigated immediately by both the contractor and the engineer. The investigation may include additional testing, and/or review and observation of the sampling and testing procedures and equipment of both parties. All work shall be documented by both parties. All deficiencies shall be resolved. If response is not made by the contractor to the engineer's request to resolve the discrepancy, the engineer may stop production until action is taken and the conflict shall be handled in accordance with Section D, herein.

C.3. Independent Assurance Testing. Independent assurance review of the contractor quality control and the Department verification sampling and testing will be done in accordance with the Department's Independent Assurance Program which may include:

1) split sample testing;
2) proficiency sample testing;
3) witnessing sampling and testing;
4) test equipment calibration checks;
5) review of the required worksheets and control charts;
6) request the testing personnel to take additional samples and perform the testing.

The independent assurance test results will be plotted on the contractor's quality control charts in accordance with Subsection B.6.1. These results will not be included with the four point running average.

Correlation tolerances used for comparison of the project and independent assurance test results are listed below.

Sieves	Allowable Tolerances Percent Passing by Weight
1 1/2 inches	±6
1 inches	±6
3/4 inches	±6
1/2 inches	±6
3/8 inches	±6
No. 4	±5
No. 8	±4
No. 16	±4
No. 30	±4
No. 50	±3
No. 100	±2
No. 200	±1.5
Aggregate Moisture	±0.5% by weight
Mix Air Content	±0.5%
Slump	± 1/2”

If a deficiency is identified, and after further investigation confirmed, a resolution will be sought. If response is not made by the contractor to cooperate in the resolution of identified deficiencies, the engineer may stop production until action is taken and the conflict shall be handled in accordance with Section D, herein.

D. Dispute Resolution.

D.1. General. Every effort should be made by the contractor and the engineer to avoid conflict. If a dispute between some aspect of the contractor’s and the engineer’s testing program does occur, a mutually agreeable solution should be sought by the project personnel. This may be accomplished through review of data, data reduction and analysis, an evaluation of sampling and testing procedures, and/or additional testing.

If the dispute cannot be resolved by the project personnel and the dispute is of sufficient magnitude to affect payment or result in an inferior product, then third party testing shall be used to resolve the difference and provide a means to minimize adversarial relationships and claims. The Department's Central Office Laboratory, or a mutually agreed on independent testing laboratory, will be asked to provide this testing. The engineer and contractor will abide by the results of the third party tests. Service charges incurred for testing by an independent laboratory will be paid by the party found in error. The additional test results may be used to evaluate the

quality of questionable materials and determine the appropriate payment in accordance with other provisions of the specification and the Subsection 106.5 of the Standard Specifications.

If the conflict involves interpretation or enforcement of this special provision which cannot be resolved by the project personnel, then a member of the specification development committee will be called upon to explain the intention of the specification and help to resolve the dispute.

D.2. Pavement Thickness. Resolution of a disputed thickness will be based on coring. Dispute resolution coring will be performed by the contractor as prescribed in AASHTO T 24 and evaluated by the engineer as prescribed in AASHTO T 148. Costs associated with dispute resolution coring will be shared equally by the contractor and the Department.

E. Concrete Pavement Pay Adjustment Documentation. Pay adjustments for Concrete Pavement will be based on compressive strength, profilograph, and thickness, as detailed respectively in Subsections G.2.1, G.2.2 and G.2.3, herein. Documentation for pay adjustment shall be submitted, by the contractor, as soon as the information for that characteristic is available. Documentation shall be in accordance with the forms provided in the Procedure Manual.

F. Method of Measurement. The item of Quality Control Program, Concrete Pavement will be measured for payment by the square yard. The quantity of this item shall be equal to the quantity of concrete pavement completed, accepted and measured for payment under the item of Concrete Pavement.

G. Basis of Payment.

G.1. Quality Management Program, Concrete Pavement. Quality Management Program, Concrete Pavement, measured as provided above, will be paid for at the contract unit price per square yard, which price shall be full compensation for all activities and documentation specified herein, and all labor, tools, equipment and incidentals necessary to complete this item of work.

G.2. Concrete Pavement Pay Adjustments. Subsections 415.7.1.1 and 415.7.1.2 of the Standard Specifications are deleted and replaced with the following:

Incentive payments or disincentive pay reductions for concrete pavement will be based on compressive strength, profilograph, and thickness, as detailed in the following subsections. These pay adjustments will be based on the quality control test results, unless other acceptance means are determined through Section D, Dispute Resolution. Test result documentation for pay adjustment shall be submitted in accordance with the forms provided by the Department.

Except for pay adjustments provided by Subsections G.2.1, G.2.2 and G.2.3, the quantity of material completed and accepted will be paid for at the contract unit price per square yard for concrete pavement, which price shall be full compensation for furnishing, hauling, preparing,

placing, curing and protecting of all materials, including cement, concrete masonry, joints and joint materials, dowels and tie bars, unless otherwise

provided; for preparing foundation, unless otherwise provided; for filling core holes; and for all labor, equipment, tools, and incidentals necessary for constructing the pavement complete, exclusive of reinforcement.

G.2.1 QMP, Incentive/Disincentive for Concrete Pavement Compressive Strength. The incentive payment or disincentive pay reduction for compressive strength of concrete pavement in each lot will be based on the contractor's quality control test cylinders fabricated for each sublot that make up the lot. The lot's pay adjustment will be based on the average strength minus one standard deviation of the strength cylinders as follows:

1. Determine the lot's average strength and sample standard deviation according to the Procedure Manual. These computations shall not include compressive strength test results from sublots documented to include concrete with air content less than the lower control limit. Compressive strength test results from all other full, partial, or combined sublots shall be weighed equally. This shall include the sublot cylinder strength test results less than 2500 psi if the material is left in-place.

2. Pay adjustment per square yard of material in the lot shall be based on the lot's average strength minus one standard deviation. The dollar per square yard adjustment for incentive payment or disincentive pay reduction will be determined from the following table:

Average - SD (psi)		Pay Adjustment (Dollars per sy)
Greater Than or Equal To	Less Than	
	2850	-0.552
2850	2950	-0.527
2950	3050	-0.452
3050	3150	-0.385
3150	3250	-0.309
3250	3350	-0.234
3350	3450	-0.167
3450	3550	-0.109
3550	3650	-0.050
3650	3750	0.000

Average - SD (psi)		Pay Adjustment (Dollars per sy)
Greater Than or Equal To	Less Than	
3750	3850	+0.067
3850	3950	+0.125
3950	4050	+0.167
4050	4150	+0.201
4150	4250	+0.226
4250	4350	+0.242
4350	4450	+0.259
4450	4550	+0.268
4550	4650	+0.268
4650		+0.276

This unit pay adjustment will be applied to the total area of concrete pavement in the compressive strength lot completed, accepted, and measured for payment under the item of Concrete Pavement, except for the following condition. In no case will a compressive strength bonus be paid on the quantity of material that has been determined to have air content outside the control limits. This material shall be identified in accordance with Subsection B.7.5, herein.

G.2.1.1. QMP, Concrete Pavement Compressive Strength Incentive, Item 90412. The QMP, Pavement Strength Incentive, Concrete, shown on the Schedule of Items, will be paid in

the contract unit of dollars. The amount shown is approximately 80 percent of the maximum attainable incentive payment for compressive strength. The incentive payment

that the contractor will receive for concrete compressive strength will be in accordance with the above table, and will be paid for as a percentage of the dollar amount shown on the Schedule of Items. The actual percentage may be more or less than 100 percent of the amount shown.

G.2.2. Incentive/Disincentive for Concrete Pavement Profile Index. Incentive payment or disincentive pay reduction for profile index will be based on the initial 0.01 inch blanking band profile index determined for each 0.1 mile lane length section or partial lane length section, prior to diamond grinding or any corrective work. If the contractor elects to remove and replace a section, the pay adjustment will be based on the initial profile index obtained on the section after replacement. Areas excluded from the profilograph testing will not be subject to price adjustments.

When the plans dictate an area of pavement to be hand finished, the area will not be subject to reduced payment. However, the area is to be profiled and corrected as necessary to meet these specifications.

The dollar per 0.1 mile lane section pay adjustment will be determined from the following table:

Profile Index (in/mile)	Pay adjustment per 0.1 mile section per lane
<19.0	+$585
≥19.0 to <25.3	+$350
≥25.3 to <44.4	$0
≥44.4 to <50.7	-$230
≥50.7	-$940

A fractional pay adjustment will be computed for each partial lane length section as a representative fraction of a 0.1 mile lane length section .

G.2.2.1. QMP, Concrete Pavement Profile Index Incentive, Item 90411. The QMP, Profile Index Incentive, Concrete Pavement, shown on the Schedule of Items, will be paid in the contract unit of dollars. The amount shown is approximately 80 percent of the maximum attainable incentive payment for profile index. The incentive payment that the contractor will receive for profile index will be in accordance with the above table, and will be paid for as a percentage of the dollar amount shown on the Schedule of Items. The actual percentage may be more or less than 100 percent of the amount shown.

G.2.3. Disincentive for Concrete Pavement Thickness. Disincentive pay reduction for thickness will be based on the average pavement thickness deficiencies for each 250 foot

lane length unit or partial unit. Pay reduction will be in accordance with the following table:

Average Thickness Deficiency	Pay adjustment per 250 foot lane length unit
0 to ≤3/8 in	$0
>3/8 to ≤1/2 in	-$1143
>1/2 to ≤3/4 in	-$2095
>3/4 to ≤1 in	-$2667

A fractional pay adjustment will be computed for each partial lane length unit and special unit as a representative fraction of the 250 foot lane unit length.

Areas of pavement determined to have deficient final thickness, as prescribed in Subsection B.7.8.5.3, herein, shall be either:

1. Removed and replaced by the contractor with concrete pavement of acceptable thickness and paid for at the full contract price per square meter.

2. Left in place, if permitted by the engineer, and not paid for.

(092598)

B. Pilot Project P200, W/Cm, Air & Temperature Test Results Summary

QMP, Concrete Pavement Pilot Project
Summary Data

	STH 29 Clark Co.	USH 10 Winnebago Co.	USH 10 Waupaca Co.	STH 11 Green Co.	USH 151 Dodge Co.
P200 - Percent					
n	31	14	19	9	14
Average	0.93	0.91	0.62	1.33	1.53
Std. Dev.	0.23	0.27	0.118	0.189	0.114
Fine Agg. - Percent Moisture					
n	31	14	19	9	14
Average	9.49	3.35	3.34	5.7	5.31
Std. Dev.	1.22	0.62	0.459	0.686	0.76
Coarse #1. - Percent Moisture					
n	31	14	19	9	14
Average	2.85	1.27	1.86	4.49	0.65
Std. Dev.	0.45	0.71	0.334	0.528	0.11
Coarse #2. - Percent Moisture					
n	---	14	19	9	14
Average	---	1.07	0.96	3.91	0.63
Std. Dev.	---	0.37	0.206	0.699	0.13
Mix Water - Lbs/CY					
n	31	14	19	---	14
Average	123.9	174.5	176.1	---	212
Std. Dev.	11.87	10.86	8.69	---	19.85
W/Cm Ratio					
n	31	14	19	---	14
Average	0.41	0.34	0.371	---	0.447
Std. Dev.	0.027	0.023	0.012	---	0.048
Air Content - Percent					
n	88	66	24	15	37
Average	7.6	7.23	6.7	6.54	7.04
Std. Dev.	0.41	0.75	0.54	0.78	0.41
Conc. Temperature - F					
n	87	43	24	15	37
Average	77	80.3	76.71	81.47	64.78
Std. Dev.	3.77	3.27	2.74	1.85	2.96

C. Compressive Strength AQL and RQL Determination

QMP, Concrete Pavement Provision

Determination of the Compressive Strength AQL and RQL

The provision's incentive/disincentive strength pay adjustment is based on the position of a lot's strength distribution. Strength limits for pay adjustments are based on an engineering analysis that defined the acceptable quality level (AQL) and the rejectable quality level (RQL). These limits define how good the strength has to be to meet the design criteria (AQL) and how bad it can get before rejection is considered (RQL). Acceptable and rejectable strength is defined in terms of magnitude (average) and level of variability (standard deviation). These strength levels are linked to values used in the pavement thickness design and supported by performance in the field.

To define the AQL for a pavement lot of this provision, the average strength chosen was 4250 psi and the standard deviation chosen was 550 psi. This average strength was based on the mean modulus of rupture used for WisDOT pavement thickness design. The chosen standard deviation was based on data collected from 26 mainline WisDOT projects. Also, the American Concrete Institute has identified 500 to 600 psi as the standard deviation of "good" strength control for general construction testing.

For the RQL of this provision, the committee chose a rejectable 28-day compressive strength value of 2500 psi. This compressive strength value is based on the working stress of the concrete as used in WisDOT thickness design. A 95 percent level of reliability was chosen to locate the normal distribution for the RQL. This means that if more than 5 percent of the strengths are below 2500 psi, the concrete will be considered for rejection. Given a standard deviation of 550 psi, the desired minimum strength, and the level of reliability, the average value of normal distribution for the RQL was determined as 3400 psi.

The percent within limits (PWL) approach for pay adjustment, considers the area below the strength distribution curve to the right of a lower specification limit. Here the lower specification limit, of 3700 psi, was calculated such that 84.13% of the area under the AQL distribution lies to the right of it. The committee chose 84.13% for the AQL area because from the lower specification limit to the average strength is a single standard deviation (550 psi). For the RQL distribution, 29.56% of the area under the distribution lies to the right of the lower specification limit of 3700 psi. If the area of strength distribution to the right of the lower specification limit is greater than the AQL area (84.13 %), incentive pay is given. If that area is between the RQL and AQL area (29.56 to 84.13%), a partial disincentive is imposed. If that area is less than the RQL area (29.56%), the maximum disincentive is applied.

D. Pilot Project Compressive Strength Test Results Summary

QMP, Concrete Pavement Provision
1997 Pilot Project Data
Compressive Strength Incentive/Disincentive Review

STH 29, Clark County, Streu Construction						
Lot Number	Number of Sublots	Days of Paving Per Lot	Average, psi	Standard Deviation psi	Pay Strength psi	Lot Pay Adjustment $/sy
1	7	1	3842	381	3460	-$0.251
2	7	1	4024	511	3513	-$0.251
3	7	2	4164	355	3809	$0.069
1	8	2	3885	383	3502	-$0.251
2	7	2	3673	220	3453	-$0.251
3	5	1	3832	273	3559	-$0.113
4	4	1	3802	224	3578	-$0.113
5	5	1	3853	264	3589	-$0.113
6	6	1	4132	263	3869	$0.125
7	6	1	4562	428	4133	$0.203
8	5	1	4313	609	3704	$0.000
9	7	2	4276	517	3758	$0.069
10	5	1	4021	315	3706	$0.000
11	5	1	4255	471	3784	$0.069
12	4	4	4045	249	3796	$0.069

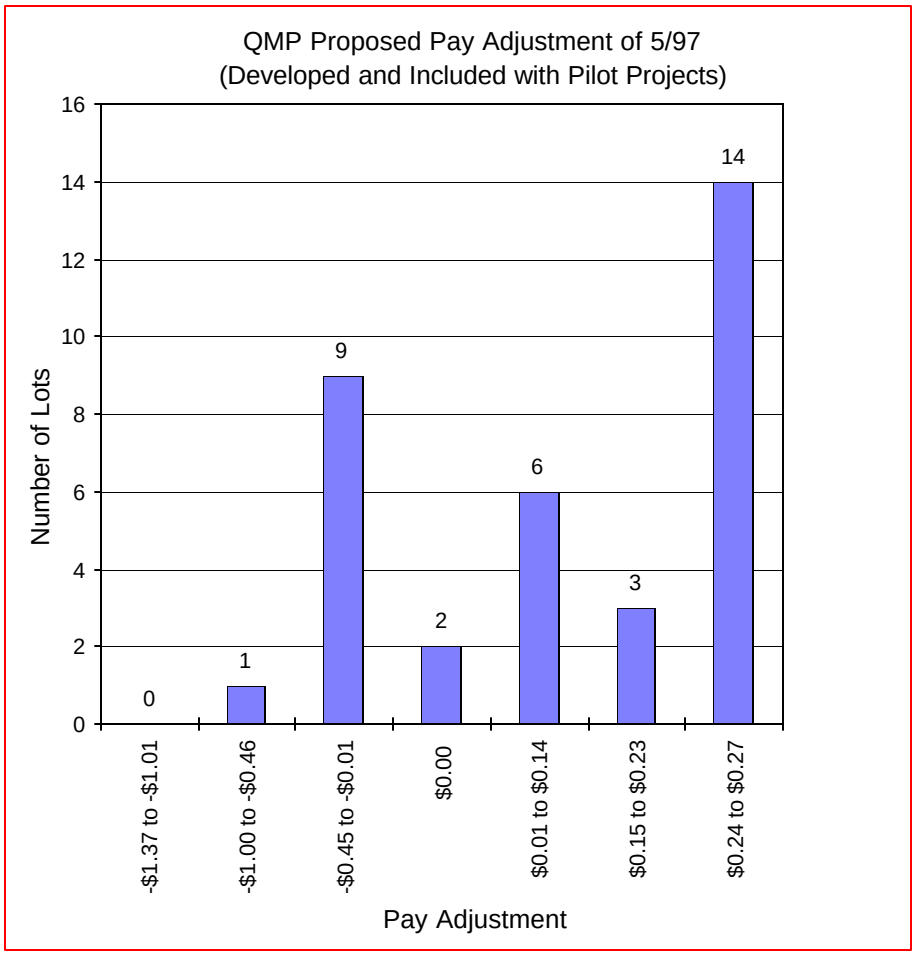
USH 151, Dodge County, James Cape & Sons						
Lot Number	Number of Sublots	Days of Paving Per Lot	Average, psi	Standard Deviation psi	Pay Strength psi	Lot Pay Adjustment $/sy
1	5	1	4917	318	4599	$0.266
2	6	1	4973	746	4228	$0.224
3	4	1	5003	210	4793	$0.272
4	7	1	5218	531	4686	$0.268
5	6	1	5040	292	4748	$0.268
6	5	1	4427	390	4037	$0.167
7	4	1	4008	691	3317	-$0.579

USH 10, Waupaca County, Trierweiler Construction						
Lot Number	Number of Sublots	Days of Paving Per Lot	Average, psi	Standard Deviation psi	Pay Strength psi	Lot Pay Adjustment $/sy
1	6	1	4183	364	3819	$0.069
2	6	1	4694	256	4438	$0.255
3	6	1	4591	166	4425	$0.255
4	6	1	4561	206	4355	$0.255
5	7	1	4702	81	4621	$0.266

USH 10, Winnebago County, Vinton Construction						
Lot Number	Number of Sublots	Days of Paving Per Lot	Average, psi	Standard Deviation psi	Pay Strength psi	Lot Pay Adjustment $/sy
1	6	2	5265	363	4902	$0.272
2	9	2	5255	404	4851	$0.272
3	6	1	5344	386	4957	$0.272
4	6	1	5521	246	5275	$0.272
5	6	1	5631	337	5294	$0.272
6	9	2	5964	443	5522	$0.272

STH 11, Green County, Zignego						
Lot Number	Number of Sublots	Days of Paving Per Lot	Average, psi	Standard Deviation psi	Pay Strength psi	Lot Pay Adjustment $/sy
1	7	2	3868	295	3571	-$0.113
2	5	2	3916	275	3641	-$0.113
3						

QMP, Concrete Pavement Provision
1997 Pilot Project Data
Compressive Strength Incentive/Disincentive Review



Note: Data collected from five pilot projects.
35 Total Compressive Strength Lots.

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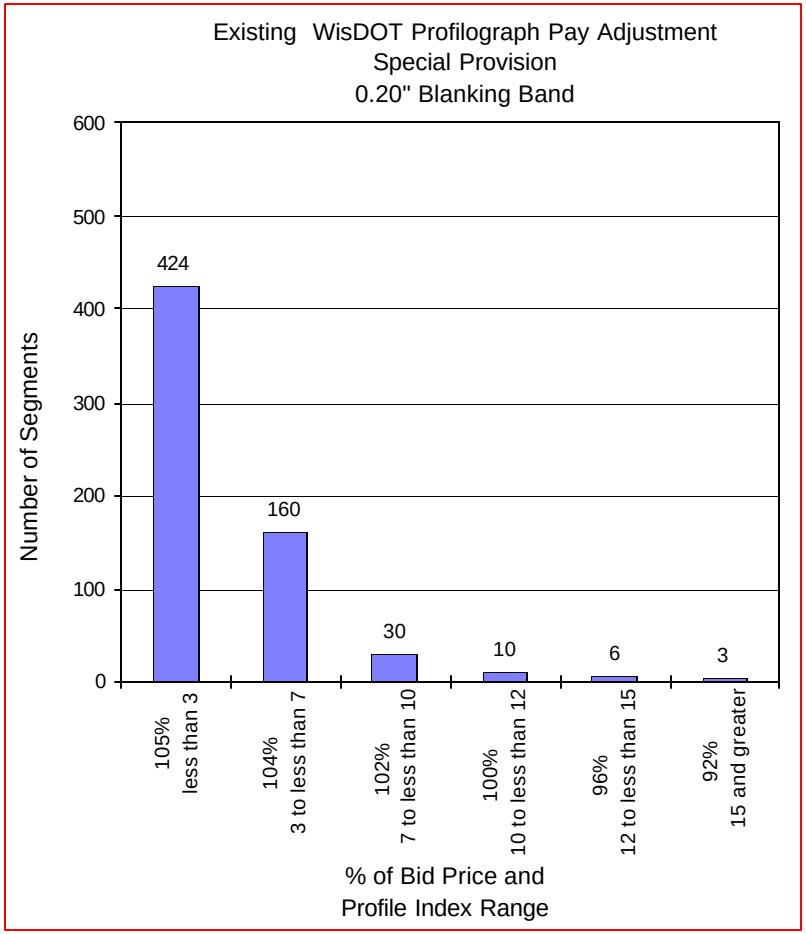
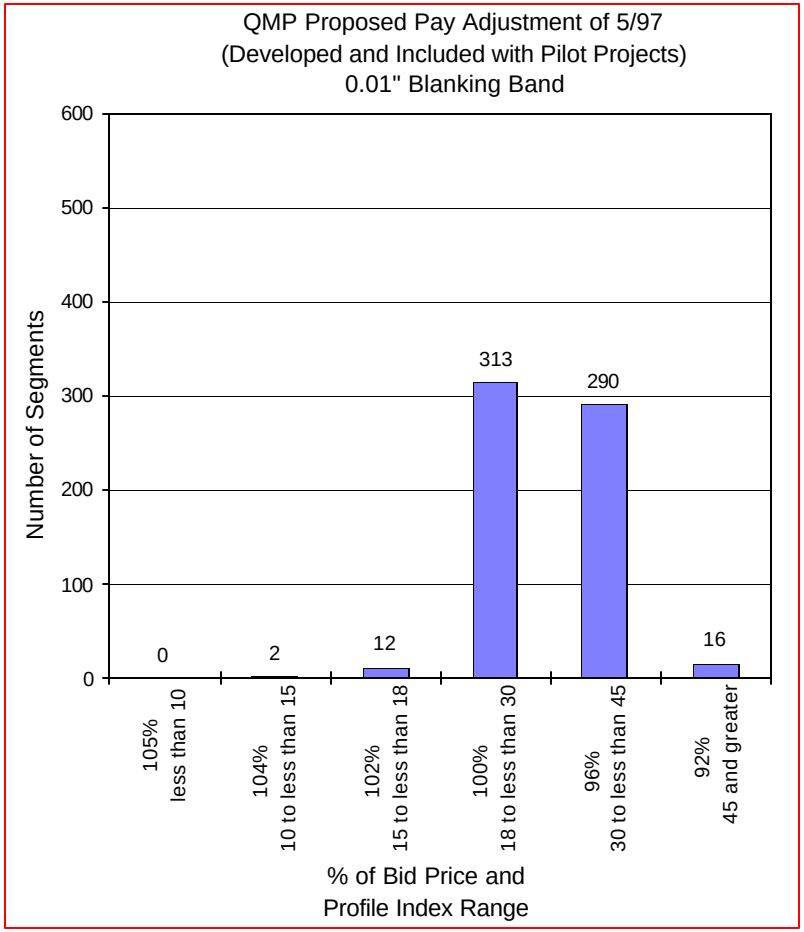
E. Pilot Project Profilograph Test Results Summary

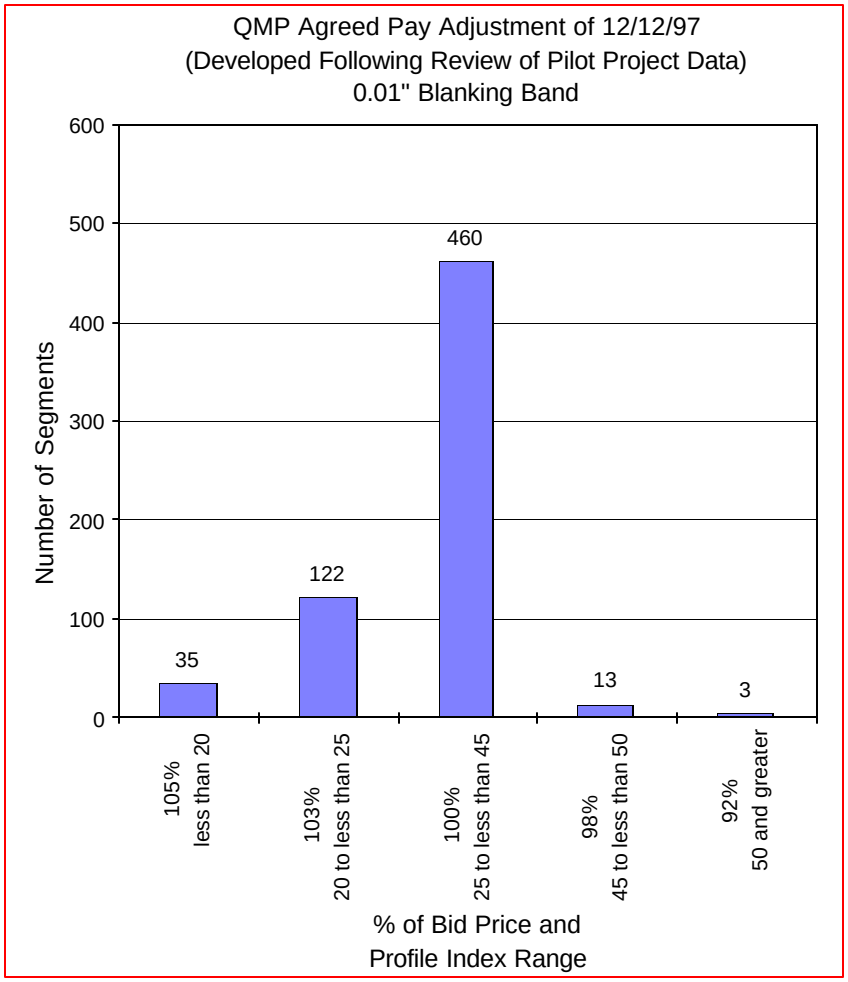
QMP, Concrete Pavement Provision
1997 Pilot Project Data
Profilograph Incentive/Disincentive Pay Adjustment Review





Note: Data collected from five pilot projects.
633 Total Profilograph Test Sections.

QMP, Concrete Pavement Provision
1997 Pilot Project Data
Profilograph Incentive/Disincentive Pay Adjustment Review



Note: Data collected from five pilot projects.
633 Total Profilograph Test Sections.

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